Finger Lakes LPG Storage, LLC

Finger Lakes LPG Storage Facility
Reading, New York

Reservoir Suitability Report

Filed: May 14, 2010

TABLE OF CONTENTS

Finger Lakes LPG Storage, LLC

Reservoir Suitability Report[1]

1. Introduction

In August 2008, Inergy Midstream acquired US Salt, LLC (US Salt) and its property located in the Town of Reading, Schuyler County, north of the Village of Watkins Glen, New York. A general location map is attached as **Exhibit 1**. US Salt and its predecessors[2] at the Facility have been in the business of salt production for over 100 years by solution mining underground salt deposits on property adjacent to Seneca Lake. In order to utilize the depleted salt caverns owned by US Salt, Inergy Midstream formed Finger Lakes LPG Storage, LLC (Finger Lakes) for the purpose of storage of Liquid Petroleum Gas (LPG) in the form of propane and butane. In order to do so, several of the old wells/galleries have been reentered to determine integrity. This Reservoir Suitability Report presents information based on known geology of the salt deposits, US Salt company files, public records and publications, competency of overlying formations, hydraulic pressurization of wells and caverns and a Finite Element Analysis to demonstrate integrity of these caverns and the ability to safely retain LPG.

2. Project Overview

Finger Lakes plans to construct an LPG (liquid propane and butane) storage system with a pipeline connection and rail and truck load/unload racks. LPG (Butane or propane) will be stored in caverns in the Syracuse Salt formation on property owned by Finger Lakes' affiliate, US Salt.

Specifically, Finger Lakes plans to convert **Gallery 1** (wells 33, 43, 34 and 44 after workovers and new wells are drilled) and **Gallery 2** (well 58)[3] to LPG storage service according to the plans set forth in this Report. See **Exhibit 2**, which includes the required maps.

The cavern(s) in each gallery will initially be full of brine (as they are now). A multi-stage split case centrifugal pump will be used to transfer product to the cavern from the TE Products Pipeline Company, LLC ("TEPPCO") pipeline or via rail or truck. During the injection cycle, brine will be displaced out the bottom of the cavern as the LPG is pumped in the top. The process will be reversed during the withdrawal cycle when brine is pumped into the bottom of the cavern and LPG is withdrawn from the top.

---

[1] This report was prepared by John Istvan of International Gas Consulting (IGC), with the assistance of K. Fuenkajorn, Ph.D., P.E., Leonard Dionisio, Barry Moon, and Barry Cigich. It supersedes the Report submitted with Finger Lakes' initial application submittal of October 9, 2009.

[2] US Salt's predecessors at the Facility include Cargill, Akzo-Nobel, Akzo and International Salt.

[3] In the previously submitted Reservoir Suitability Report, Finger Lakes Gallery 2 consisted of wells 30, 31 and 45. Finger Lakes Gallery 2 now consists of well 58.

A surface pressure of approximately 1000 psi will be maintained when the well is closed and a minimum of 500 psi when in operation when LPG is in the cavern, depending on the surface elevation of the well and depth of the cavern.

LPG can be received by pipeline (TEPPCO), truck or rail. The pipeline will feed the suction of the high pressure pump for injection directly into the cavern in the injection cycle at an initial design rate of 5,100 Barrels Per Day (BPD) to 48,000 BPD. The railrack (to be constructed on property recently acquired by Finger Lakes) is capable of loading or unloading 24 rail cars in 12 hours with space to park 24 rail cars. Surge capacity (bullet storage tanks) will consist of 5-30,000 gallon vessels, which can be used for butane or propane. The truck rack is capable of loading or unloading 30 trucks/day.

A transfer pump system utilizing centrifugal "can" pumps will be installed to load trucks and to supply the required Net Positive Suction Head (NPSH) to the high pressure pumps. A vapor circulation system utilizing compressors will be used to unload rail cars or trucks.

Propane will be withdrawn through a dehydration system to remove any water vapor from the product.

Brine circulated from the caverns will be stored in an above-ground pond. All brine will be circulated through a separator with an active flare before being transferred to storage in the pond.

Out of the existing sonar determined storage capacity for Gallery 1 (wells 33, 43, 34 and 44) of approximately 5 million barrels, Finger Lakes requests authorization to store 1.5 million barrels of LPG in this Gallery.

Finger Lakes seeks authorization to store up to 600,000 barrels of LPG in Gallery 2 (well 58).

3. Location and Regional Geology

The Watkins Glen brine field, located in Schuyler County, is in the south central part of New York State, along the west shore of Seneca Lake. See the general location map in Exhibit 1. It is approximately 2 miles north of the village of Watkins Glen. Physiographically, the region is part of the Finger Lakes district of the Allegheny plateau that has been peneplaned, uplifted and glaciated. Due to glaciation, the area is marked by deep valleys that are now occupied by the Finger Lakes and hanging tributary valleys. Rocks that outcrop in the area are Devonian Age sedimentary formations that dip gently to the southwest. The terrain rises steeply across the site toward the west from the lake shore at about 270 feet/quarter mile. The site is covered with native vegetation.

Sediments encountered by wells drilled in the brinefield range in age from Upper Devonian, Genesee shales, to the Upper Silurian, Salina group, Syracuse salt and underlying Vernon shale. Several stratigraphic columns are included in **Exhibit 3**.[4] Sediments are composed of shales, sandstones, limestone and dolomites with the shales of the Middle Devonian, Hamilton group, being 800 feet in thickness and separated from the upper Devonian shales by about 30 feet of middle Devonian Tully limestone. The Hamilton group is underlain by the middle-lower Devonian, Onondaga limestone that overlies the lower Devonian Oriskany sandstone. The Oriskany is rather sporadic in occurrence and has not been identified in all wells.

Below the Oriskany, sediments of the Upper Silurian, Bertie and Salina groups are encountered and consist of limestone, dolomite, shale, anhydrite and evaporate salt beds. The salt being dissolved is part of the Syracuse salt formation that is a member of the Salina group of the Cayugan series of the Upper Silurian system. It consists of six distinct beds with the possibility of a thin salt stringer some 40 feet below the sixth salt. See Exhibit 3. The salt beds are intensely folded into a series of local east-west anticlines and synclines with only a few tens of feet from crest to crest (Jacoby, 1963, p. 508). See **Exhibit 4**. It is likely that the salt and incompetent shales of this section flowed plastically and absorbed the shock of the regional tectonic force during the Mesozoic era, and gave rise not only to the intense folding, but also faulting of the salt section. This is apparent when the structure of the salt is compared to the overlying sediments. The overlying sediments are characterized by broad, gentle east-west synclines and anticlines with axes generally paralleling the sharp folds of the underlying evaporites. On the basis of the cores from the Watkins Glen brine fields (see Section 7.3 below), some beds appear to pinch out completely while others double in thickness over a distance of 300-400 feet. Inergy experience is that the gross thickness of the Salina salt beds across the field have been faulted and folded along the decollement at the base of the salt as is the case throughout the New York and Pennsylvania salt basin.

4. Historical Development of Salt Caverns and Previous Usage for Hydrocarbon Storage

The US Salt caverns and wells have had a limited productive life (for brining and salt production purposes) because they have relied on "reverse injection" after the wells are hydraulically connected by fracturing, according to Jacoby. That is, water was injected near the top of the salt to form "morning glory" cavern shapes. That method of brining leaves large volumes of undissolved salt in the ground. In addition, broken brine return tubing from accelerated brining and encountered ledges in some caverns have led to early abandonment. [redacted]

Improvements in solution mined bedded salt technology have shown that [redacted]

[4] See also Exhibit 17, which provides as part of the cross sections prepared for this report a stratigraphic column with Rickard designations.

5. Well Construction and Well History

Finger Lakes Gallery 1

Wells 33, 34, 43 and 44 were drilled in 1961, 1961, 1966 and 1967 respectively, plugged and abandoned in 1976, 2004, 2004, and 2004 respectively and reentered in early 2009 by Inergy.

When wells 33, 43, 34 and 44 were drilled out and reopened,[5] there was [redacted]

[redacted]

When wells 33, 34, 43, 44 were drilled out and completed with temporary well head valves, [redacted] (difference in well head elevation). [redacted]

On that basis, Inergy and US Salt performed a hydrotest of the gallery in preparation ultimately for a nitrogen/brine interface mechanical integrity test of the gallery. See Section 6.2 for successful hydrotest data.

Finger Lakes Gallery 2

Well 58 was drilled in October 1992 for use as a natural gas storage cavern. Attached as **Exhibit 5** is the sample description and core log. Attached as **Exhibit 6** is a copy of the Compensated Neutron – Formation Density Log for the drilling activities in 1992. However, in 1999 it was believed that there was a purported roof cavern collapse[6] that filled part of the cavern with rubble. The decision was made to abandon the well in 2001 and it was plugged and abandoned in October 2003.

The well was originally drilled to develop a future natural gas storage cavern. The well was only drilled to 2,632 feet depth, short of the bottom of the salt that is projected to be found closer to [redacted]

---

[5] Wells 33, 44 and 43 were all relined. With regard to well 43, it was relined with 4" FJ 13.5# P100 pipe set at a depth of 2117 ft on 8-10-2009 and cemented to surface w/65 sks Class a +2% $CaCl_2$ to surface. This well (well 43) and Well 44 will be used as monitoring wells and for sonar surveys, and only used for product movement if necessary.

[6] Based on a recent sonar, however, there is no reason to believe now that a roof cavern collapse did in fact occur.

[redacted] last sonared before abandonment in 2003.

During the last logging of well 58 prior to plugging, the indication was that the roof of the cavern had collapsed and filled the whole cavern with rubble. Consultant Larry Sevenker further reported that a small magnitude earthquake could have damaged the cavity. This was reported to the Department in a letter dated May 24, 2001.

After further review by Inergy Midstream LLC, it was concluded that well 58 could not have been filled with rubble completely. This conclusion was based on conversations with Larry Sevenker and Jeff Childress from Micro Systems Sonar, which was the contractor conducting the sonar on well 58 in 2001. According to Larry Sevenker, at the time the 2001 sonar survey was attempted, they pulled the 4 ½" tubing up to sonar in the open hole, but were unable to get out the bottom. The 4 ½" tubing was set at 2,632 feet inside of 7" tubing set at 2,613 feet. They tried to sonar through the 4 ½" and 7" tubing on the way out, with results showing no open hole. This was the basis of their conclusion to plug the well, which as noted above was done in 2003.

Recently, Inergy once again contacted Mr. Childress about the 2001 sonar [redacted] Prior to plugging well 58, US Salt pulled out the 4 ½" and 7" tubing from the well. The 9 5/8" casing was then plugged to the surface.

Subsequently, a more recent sonar, completed in 2009, [redacted] The sonar report is attached as **Exhibit 7**. [redacted]

With DEC approval,[7] well 58 was reentered in October 2009 and [redacted]. A vertilog and new cement bond logs were run[8] and a new sonar performed. A copy of the Gamma Ray Segmented

[7] A revised well drilling permit application was submitted to DEC on September 28, 2009 for the purpose of drilling out the cement on well 58. The permit was issued on October 6, 2009.

[8] As the Department is aware, the Microvertilog and cement bond log were not completed to the bottom of the casing. When Inergy applied for a drilling permit, it listed in its procedure that drilling would stop 50 feet above where the bridge plug was located and the casing log and cement bond log would be run to make sure there was casing integrity before the plug was drilled out. Inergy did not know if any pressure would be encountered and wanted to make sure the casing was good.

Bond Log, the Gamma Ray Neutron Log and the Microvertilog for the drilling activities in 2009 are attached as **Exhibit 8**. The 2009 sonar [redacted]

All of the technical evaluation that went into the decision to abandon the cavern in 2001 was apparently made by sonaring and perhaps logging through two strings of suspended tubing that had become bent while suspended in the well during solution mining. [redacted]

Inergy is in the process of [redacted] The well is suitable for additional solution mining purposes to supply brine to the US Salt plant.[9] After the final sonar, all of the collected pressure and log data including the final sonar and MIT will be submitted for DEC approval to convert to LPG storage service.

A well status and condition report is attached as **Exhibit 9** (this replaces the previously submitted report which was included as Tab D). Diagrams of each well in each gallery, showing existing casing and cement for each plugged and unplugged well, is provided in **Exhibit 10**. Exhibits 9 and 10 also include information on wells immediately adjacent to the storage area (wells 18, 29, 52 and 57).

6. <u>Evaluation of Well and Cavern Integrity</u>

Pressure increase and stabilization was established in Finger Lakes Gallery 1 and Gallery 2. The successful hydrotest results are described in Section 6.2 below.

6.1 <u>Vertilogs</u>

Vertilogs have been run in wells 33, 43, 34 and 44 to determine remaining wall thickness of the existing wells in order to determine if those wells are suitable for underground storage of liquid hydrocarbons. The purpose of performing a vertilog is that if a well indicates poor integrity from the vertilog information or from the hydrotest, that well will either be a candidate for a new liner or will be abandoned and a replacement well drilled to move product in and out. Cemented casing in Well 34 is too small for

[9] DEC issued a permit to convert well 58 from a stratigraphic well to a brine well on March 4, 2010.

LPG storage operations and the well will be abandoned. Based on verti logging, well 44 has had a new 6 5/8 inch liner cemented for product displacement purposes. Well 33 was reworked and a new liner of 8 5/ 8 inch casing was cemented into the well[10] for this application. Well 33 will be used for injection/withdrawal and wells 43 and 44 will become monitoring wells and only for product movement as necessary.

As referenced above, a vertilog has been run in well 58 to determine casing wall thickness, a sonar for cavern shape and suitability for LPG storage. The results of the vertilog information shows that well 58 can be used as part of Finger Lakes' LPG storage operations and that there is casing integrity.

6.2 Hydrotests/Brine Pressure Tests

Hydrotesting of the caverns formed by Wells 33, 34, 43 and 44 has shown that the caverns and existing wells have pressure integrity up to a 0.8 psi/foot of depth of the casing seats.

Hydrostatic pressure testing at a gradient of 0.8 psi/foot was performed by [redacted] See attached pressure data from the hydrotest as **Exhibit 11**.

Inergy Midstream recently conducted a long term brine pressure test on well 58, which was approved by the Department. The complete submission to the Department is attached as **Exhibit 12**.[12]

On January 19, 2010, the long term brine pressure up of well 58 began with the injection of saturated brine down the tubing string at approximately [redacted]

During initial pressure up of well 58 [redacted]

[10] In addition, a 4 ½" hanging string was also installed.

[11] When wells 33 and 43 were drilled out to the cavern and open to the pressure test, wells 34 and 44 remained plugged.

[12] Inergy also conducted a Mechanical Integrity Test for EPA in connection with Inergy's request to DEC to convert the well to a brine well for further solutioning. A copy of the report to EPA, dated February 24, 2010, is attached as **Exhibit 13**.

[redacted]

The long term brine pressure test started at 11:30 am on February 8, 2010. The casing pressure at start up on well 58 was [redacted] The tubing pressure at start up on well 58 was [redacted]

The long term brine pressure test ended at 11:30 am on February 15, 2010. The ending casing pressure on well 58 was [redacted] The ending tubing pressure on well 58 was [redacted] While monitoring wells listed above, [redacted]

For the 7 day duration of the long term brine test, well 58 had a [redacted] The tubing had a [redacted] The difference in [redacted] In addition temperature was taken at time of pressure recordings to show the affects of the weather on the tubing string, because there was approximately [redacted] The pressure [redacted] Cavern pressure [redacted]

When all of the wells in both Finger Lakes Galleries 1 and 2 are completed, a nitrogen/brine MIT will be performed in preparation for injection of LPG.

6.3 Gamma Ray and Neutron Logging

Gamma ray and neutron logs have been run in the past by International Salt Company to compare the open hole logs with the status of the lithology as solution mining takes place. That comparison clearly shows where the lithology is the same as before brining commenced and after salt has been removed. These tools are important to the operation of the reservoir since repetitive and comparative logs will alert Finger Lakes to any changes that might affect the well and cavern operation. Such tools will be utilized on the same schedule as sonar surveys. See Section 9 below.

6.4 Lack of Interconnection with International Gallery 10

On November 14, 2009, Stone Drilling began drilling out well 52 (per DEC permit issued on November 6, 2009) and encountered the bridge plug[13] at 2,220 ft. When the plug was completely removed, [redacted] A chart recorder had

[13] Well 52 had been previously plugged and abandoned on April 11, 1996.

been placed on [redacted] Baker Atlas ran a segmented cement bond log and a microvertilog on the well after it was drilled out. The logs (including the sonar survey and directional survey) for the recent activity at well 52 are attached as **Exhibit 14.**[14] A directional survey (also included with Exhibit 14) was completed by Javins on November 17, 2009. A well valve was then installed and closed. [redacted] See the Finite Element Analysis (Section 8 below) for data on stability of Gallery 10 vs. well 44.

7. Suitability of Caverns to Store LPG

7.1 Methodology

As noted in Section 6.2, when the caverns for wells 33, 34, 43 and 44 were reentered, [redacted] Digital recording devices were installed on the wellheads of the US Salt and NYSEG LPG and natural gas storage caverns during the hydrostatic testing.

New sonars of caverns for the proposed Finger Lakes Gallery 1 and 2 showed the salt pillar thickness relationships between Inergy/US Salt nearest well 33 and the natural gas caverns of Seneca Lake Storage wells 27/28/46/59, as well as the planned Finger Lakes LPG storage cavern 58 (Gallery 2) .

7.2 Discussion of Geologic Cross-Sections, Faults Analysis and Jacoby

As requested by DEC, Finger Lakes has reviewed the papers of C.H. Jacoby regarding the Watkins Glen brine field.

Jacoby writes that faulting is pervasive in the brine field, resulting in alternating thinning and thickening of both salt and insoluble layers. However, that faulting is limited to the Salina salt interval, since Finger Lakes' interpretation is that there is no indication the faults extend into overlying beds or the underlying Vernon shale. The [redacted]

---

[14] Please note that the MicroVertilog included in Exhibit 14 has the incorrect year. It should read 2009.

[15] At the time the wells were re-entered for purposes of conducting hydrostatic testing, DEC asked about monitoring well 19. However, well 19, about 150 feet northeast of US Salt well 44, was never drilled.

Jacoby is correct in that the rafting of the salt from the southeast has caused rupture of the interbedded, non salt layers. However, the plasticity of salt as the gross salt thickness was thrust to the present state along the decollement has resulted in the closure of any porosity around the "faults", enclosing them with salt. Experience at other bedded salt locations has shown that whenever a layer of insolubles is undercut and falls into the bottom of a developing cavern, the space can be recovered by working the well over and adding new tubing to the injection string. In the case of the proposed Finger Lakes Gallery 1, considerable space has been retained that is suitable for hydrocarbon storage, indicating that the roof and walls have structural integrity. Since the roof span has been stable with hydraulic support from brine, then stability with liquid butane and/or propane is assured.

[redacted] There may not have been any tectonic activity in this area since the Appalachian Orogeny approximately 225 million years ago.

The Appalachian Orogeny took place starting in the Late Devonian period and continued into the Permian. This entire region of North America was subjected to compressive forces that were acting in a north-south direction creating a series of parallel folds and thrust faults that strike from east to west across the area. In addition, some high angle strike-slip faults oriented north to south have deformed the Silurian and Devonian Rocks in this immediate area.

As more wells have been drilled into salt and underground mines developed, geologists have come to a better understanding of the mechanical characteristics of salt and its response to the tectonic forces that create folding and faulting. "Faulting is a major component of most hydrocarbon traps. Many faults form the boundary plane of a pool of oil and gas, and this may be due to the fact that the fault is tightly sealed and holds the petroleum from further migration" (Levorsen, 1954). The existence of faulting does not indicate necessarily that there is a pathway for fluids to migrate.

At the US Salt brine field, Jacoby and Dellwig reported a vertical north to south trending strike-slip fault located east of brine wells 29, 37 and 41. [redacted] In the same paper Jacoby and Dellwig concluded that "[t]he structure contour map on the top of the salt gives no indications of the faults breaking up into the overlying sediments." Therefore, all of their discussion of faulting is confined to the salt and the intervening rock layers which are known to be plastic.

The Camillus shale directly overlies the Syracuse salt sequence. This shale sequence is approximately 80 feet thick across the Finger Lakes LPG Storage area. As illustrated on the attached Camillus Shale Isopach Map (**Exhibit 15**), the thickness of the

Camillus Shale varies from 78 to 82 feet thick across the brine field. The fact that the thickness of the shale is so uniform confirms the interpretation that the Camillus shale cap rock has not been compromised by faulting. If faulting had occurred, significant shortening by normal faults or lengthening in response to reverse faulting would be reflected in the thickness of the Camillus shale.

In addition, a structure map (**Exhibit 16**) has been constructed on the base of the Camillus shale reflecting approximately 30 feet of dip to the west across the brine field. The consistent dip represented on the structure map reinforces the interpretation that no faulting extends into the Camillus shale cap rock.

Cross-sections have been created to show the gallery relationships between the wells in each gallery along with the overlying formations of Camillus shale, Bertie anhydrite, Helderberg limestone, Oriskany sandstone, Onondaga limestone and Marcellus shale. The casing seat deviations are shown only where they fall along the cross-section line. The original total depths of the wells are shown and the lowest sonar depths of each well are recorded. The rubble pile thickness is the difference between the original total depth and the bottom depth recorded by the latest sonar survey.

The cross-sections (one North-to-South and the other West-to-East) also illustrate the absence of faulting and the uniformity of the Camillus shale across the Finger Lakes LPG Storage area. The cross-sections illustrate the distinct salt and "rock" units using the Rickard standardized salt unit naming convention. The cross-sections show all sonar survey outlines (appropriately labeled) and any interconnections with other wells/caverns (e.g., in Gallery 1). See **Exhibit 17**. The cross-section locations are shown on the map included in Exhibit 2, Map 1.

In conclusion, the way to determine the suitability of a cavern to store hydrocarbons is to test the cavern's pressure containment capability. Having reviewed all the evidence of the past operating data, geological and engineering studies and the results of sonars, hydrotests, vertilogs, and the successful pressure tests, Finger Lakes, as an experienced operator, has concluded that the suitability of these caverns to store LPG is assured and confirmed.

7.3 Core Test Results

Core testing has been done for well 58, which constitutes Finger Lakes Gallery 2 and well 59, which is part of Seneca Lake Storage Gallery 1. From these wells, the caprock and salt properties in the vicinity of the proposed Finger Lakes storage facility can be surmised. Cores were taken of well 58 at the time of drilling (late 1992). See Exhibit 5. Cores were taken of well 59 in late 1995. A description of the coring activities at well 59 is attached as **Exhibit 18**. Subsequently, a geomechanical analysis for these two wells was conducted in 1996. See **Exhibit 19**.

The coring that was performed in wells 58 and 59 for the Seneca Lake natural gas storage project was to determine what the Poissons Ratio, Young's Modulus, and compressive strengths are of the Watkins Glen salt deposit. That is, what were the mechanical properties of the local salt body that had been solution mined for over 100 years. The core and mechanical testing results are based on worst case conditions of the compression and tensile testing process. Core analysis and rock mechanics testing from one or two wells in a salt body are transferrable to other wells/caverns in the same salt body such as was accomplished at Savona for the finite-element analysis/geomechanical study that is being provided to DEC with this Reservoir Suitability Report.

A model has been prepared for Finger Lakes to simulate the worst case in utilizing the caverns in relation to adjacent caverns based on the wall-to-wall distance between caverns as shown on the revised map included in Exhibit 2. See Section 8 below.

The core descriptions for wells 58 and 59 verify much of what Jacoby reported in his papers including the fact that the insoluble fragments and "faults" are all enclosed with recrystallized salt and do not create a situation where an insoluble fall into the cavern means that the developing space must be abandoned.

The caprock across the area and over the caverns are dense, hard and relatively contiguous shales and dolostone/dolomites with compressive strengths over 10,000 psi. Those high compressive strengths and solid correlation of beds across the brine field attest to the competent roof span shown in the sonar surveys, in spite of the flow dynamics of the salt that have created the internal displacements that have been interpreted by others as faulting. [redacted] (see Exhibits 15 and 16). The hydrostatic pressure test that Inergy recently conducted [redacted] See Section 7.2 above. [redacted]

A study of the core descriptions from wells 58 (now Gallery 2) and 59 describe [redacted]

8. Rock Mechanics and Finite Element Analysis

The rock mechanics report for the well now constituting Finger Lakes Gallery 2 concluded that the gallery does not affect the integrity of adjacent wells, caverns and galleries, including the natural gas stored to the east in Seneca Lake Storage Gallery 1.[16] The salt and insoluble layers correlate within the south to north cross-section through the salt section.

The roof of caverns 34 and 44 is very stable and with the hydrostatic pressure testing performed by Inergy demonstrates in-situ integrity. Due to the fact that all of the caverns in the area, except the Seneca Lake Storage natural gas cavern gallery, are being supported by hydraulic pressure of brine, and later by liquid petroleum gases, there will be no integrity problems in storing liquid hydrocarbon products.

A Finite Element Analysis ("FEA") model was prepared by Dr. Kittitep Fuenkajorn, Associate Professor of Engineering at Suranaree University of Technology, Nakhon Ratchasima (Khorat), Thailand. See **Exhibit 20**. Dr. Fuenkajorn performed the exact same type of FEA for the Amoco Silver Springs LPG storage project and for the Underground Storage Permit Modification for Inergy Savona.

FEAs have been performed to assess the stability conditions of the 34/44 LPG storage gallery, gallery 10 and caverns 33 and 43 at the Finger Lakes facility, Watkins Glen, New York. Laboratory test data from related projects obtained by RESPEC Inc. were used to determine the mechanical and rheological properties of the Syracuse salt and the overburden rocks.

Two finite element models were developed to represent a vertical and a horizontal cross-section of the studied galleries and caverns in relation to the site geology. Conservative cavern geometry and boundary conditions were then imposed. The analyses were made to simulate the mechanical behavior of the surrounding salt under three extreme internal pressures through the next 50 years. These cases include (1) constant hydrostatic pressure of brine, (2) the mechanical integrity test (MIT) hydrostatic pressure (about 80% of the in-situ stress at casing shoe), and (3) the minimum LPG pressure with zero wellhead pressure. The study results are summarized as follows:

1. The inter-cavern pillars between caverns 33 and 43, 34/44 LPG gallery and gallery 10 will be mechanically stable under the minimum LPG storage pressure of 1,197 psi at the casing shoe for the next 50 years.

2. The inter-cavern pillars will be mechanically stable under the MIT hydrostatic pressure of 1,680 psi at the casing shoe for the next 50 years. The MIT pressure is lower than the predicted pillar stresses.

3. Leakage or communication between galleries and caverns under the MIT and minimum pressures is very unlikely.

[16] This conclusion applies equally to NYSEG Gallery 2 (authorized by FERC but never operated), which consists of wells 30, 31 and 45.

4. The impact of the pressure cycle is very small due to the small difference between the proposed magnitudes of the maximum and minimum storage pressures of the LPG.

5. The salt pillars have been subjected to large shear strains during brine storage/production. These strains are however significantly reduced by the increase of the confining pressures in the salt pillars when the caverns/galleries are under MIT pressure and LPG storage.

6. Certain conservative assumptions were made relating to the pressure, location and size of cavern associated with Gallery 10. Inability to access the gallery for sonar due to well conditions necessitated the use of these worst case assumptions. Although the results reflect integrity and lack of failure in all cases using these conservative assumptions, these are not necessarily representative of actual conditions present. For further assurance and maintenance of integrity in Finger Lakes Gallery 1, well 44 will be utilized as a monitoring well and no solution mining will occur in the direction of well 44.

7. Well 33 will not increase in diameter if and when it is put into LPG storage service since any 30% increase in solution mining by undersaturated brine product displacement will take place above the existing maximum diameter.

8. Wells 43 and 44 will be monitoring wells and will not be solution mined (i.e., those wells have no affect on the modeling).

In addition, the FEA report concluded that "[b]oth well 58 (far away and not on the FEA map), and NYSEG Galleries 1 (natural gas storage service), and 2 are also too far away to have any affect on the Finger Lakes (FL) LPG storage caverns."

9. <u>Sonar Reports and Surveys</u>

There will not be any solution mining in preparation for the conversion of Gallery 1 to hydrocarbon storage. Gallery 1 has been sonared in 2009 and additional sonar will not be required until 2019.

Out of the existing sonar determined storage capacity for Gallery 1 (wells 33, 43, 34 and 44) of approximately 5 million barrels, Finger Lakes seeks authorization to store 1.5 million barrels of LPG..

With regard to Gallery 2 (well 58), the 2009 sonar indicated a capacity of approximately 600,000 barrels (including rubble). Sonar will be conducted again after solutioning (a permit to convert this well to a brine well for solutioning was recently issued by DEC) and then ten (10) years after. Once the additional solutioning is completed, Finger Lakes estimates that well 58/Gallery 2 will have a storage capacity of approximately 700,000 barrels. With this application, Finger Lakes is seeking authority to store 600,000 barrels of product.

Over the life of the caverns, Finger Lakes expects total growth in each gallery not to exceed 30%, based on the Capacity Matrix contained in the table attached as **Exhibit 21**.

10. Minimum and Maximum Storage Pressures

Salt caverns in LPG storage remain full of liquid at all times. The fluid pressure in the well and cavern depends on the height of the column of fluid(s) in the well and the weight of the fluid in the column. There are two columns of fluid in the LPG storage well. The well casing is cemented into the rock formations and goes from the surface to a point just above the salt layer, ending at the "casing shoe." A tubing string is hung from the wellhead and passes down through the inside of the cemented production casing, past the casing shoe to near the bottom of the cavern. The tubing is full of either brine or fresh water. The space around the tubing inside the casing is called the annulus. The annulus is filled with brine when the cavern is empty and with LPG when the well is in storage service. Storage is accomplished by pumping LPG down the annulus and displacing brine out from the cavern into the tubing to the surface. Recovery of product is accomplished by pumping brine or water into the tubing and displacing LPG back out of the cavern up the annulus to the surface facilities. The well/cavern system is a closed system.

The pressures at the casing shoe and in the cavern are always controlled by the weight of the column of fluid in the tubing. The pumping pressures are the pressures required to overcome the weight of brine or LPG in their respective columns plus the friction acting against the flow.

Finger Lakes' proposed maximum and minimum operating storage pressure is based on constant LPG or brine pressures in the wells and caverns making up each of the galleries. The wells will be operated in parallel and will all be at the same pressure, either under hydraulic pressure of brine or LPG pressure. On that basis there are no technical reasons why Gallery 1 would not be stable in the future after passing the nitrogen/interface MIT since the walls and roof of the cavern/gallery are always fluid supported.

The rock mechanics and finite-element analysis evaluations being provided by Finger Lakes with this application assumed a 0.8 psi/foot pressure to the casing seat in their analysis. Finger Lakes hydrostatic testing in proposed Gallery 1 was at 0.8 psi/foot, in excess of the favorable testing performed by Seneca Lake Storage. The Gallery 2 pressure testing was also 0.8 psi/foot. Since the salt in the field is similar throughout, Finger Lakes as a prudent operator, will test with nitrogen/brine MIT at 0.75 psi/foot at the casing seats in both new and existing wells in Galleries 1 and 2 before product is injected into those wells.

The maximum and minimum storage gradients at the wellhead and casing shoes will be as follows:

	Min Grad	Max Grad
Well 33 – casing seat cemented at 1,975'	[redacted]	[redacted]
Well 43 – casing seat cemented at 2,117'		
Well 34 – Plugged and Abandoned – 2010'		
Well 44 – casing seat cemented at 2,423'	[redacted]	[redacted]
Well 58 – casing seat cemented at 2,183'		

These pressures are well below those assumed in the FEA.

11. Cavern Development Plan

Finger Lakes Gallery 1

No additional solution mining is planned for the Finger Lakes Gallery 1 consisting of well 33, 43, 34 and 44 caverns. That existing space is suitable for storage of hydrocarbons based on the work that has been performed. The recent reworking of each of these wells included sonars and hydrotesting, and as a result demonstrated the lack of pressure interference with adjacent wells and caverns when the hydrotest test was run on the wells. The increase in cavern dimensions will be about 1-2% annually by the displacement of hydrocarbon products with slightly undersaturated brine, and then because the gallery is so large, the increase might not be noticeable by sonar survey since additional insolubles will accumulate on the cavern bottom, reducing the usable cavern volume.

The Baker Atlas Segmented cement bond log for well 33 run on January 26, 2009 [redacted] The casing seat is at 2,000 feet, top of cavern = 2,013 feet, and Top of salt = 2,014 feet. Tubing (8 $^5/_8$") was installed at 1,975 feet and cemented to the surface. Tubing (4 ½") was also set at 2,220 feet and hung in the new wellhead. As noted above, no increase in cavern size will occur since the well will primarily be used as a monitoring well.

In order to convert to LPG storage, well 34 will be plugged and abandoned since the production casing is too small for the planned storage injections and withdrawals. A new well (FL #1) will be drilled and cemented into the salt between wells 34 and 44 at the high point determined by the combined sonar surveys of those two wells. This new well and well 33 will be the primary injection/withdrawal wells. Wells 43 and 44 will be used for the most part as monitoring wells and for sonar surveys, and only used for product movement if necessary. A permit application for this new well *(FL # 1)* will be submitted upon receipt of the underground storage permit as will an application to convert the status of wells 33, 43 and 44.

Finger Lakes Gallery 2

Well 58 will be subjected to a nitrogen interface MIT before being placed into LPG storage. The well is suitable for additional solution mining purposes to supply brine to the US Salt plant and DEC recently issued a permit for this. After the final sonar and nitrogen interface MIT are completed, all of the collected pressure and log data including the final sonar and MIT will be submitted for DEC prior to commencing LPG storage service. Additional solution mining of well 58 will not increase the maximum diameter outline shown on all the enclosed maps.

12. Review of Historic Earthquake Activity

Based on data compiled by the National Geophysical Data Center and updated by IGC using USGS data, there are no risks involved at the site with earthquakes within ½ mile of any of the subject Galleries. See attached **Exhibit 22.**

13. Subsidence Monitoring

US Salt has been monitoring the elevations of wellheads and other subsidence monuments for decades and providing a report every 5 years. Experience has shown that as many monuments show a reduction in elevation as show an increase in elevation. Much of the changes in elevation are due to the change in the weather from warm to cold. This phenomenon is universal and documented surveys show that there has been no significant subsidence across the field mainly due to the stiffness of the overlying formations.

At the DEC's request, Finger Lakes will conduct subsidence monitoring at least every two (2) years at all injection, withdrawal, monitoring and plugged wells in each gallery. More specifically, Finger Lakes proposes to conduct bi-annual subsidence monitoring on wells in Gallery 1 (well 33, 34, 43, 44 and FL 1 (when drilled), and Gallery 2 (well 58). Monuments will include Mon 20/42, Mon 20/02, BM 77-1, BM 77-2, BM 77-3 and BM USGS95 which are used by US Salt for their subsidence program.

14. Safety Procedures and Emergency Shutdown

Evidence of well and cavern problems can be quantified simply by careful recording of product injection and comparison with product withdrawal. In most cases, the amount of product injected, much like the ups and downs of subsidence monuments, can be more than what is withdrawn, or vice versa. It becomes obvious however, when product or brine are lost in large numbers. Prudent operators will quickly shut-in operations when pressures do not respond to the norm. Finger Lakes is cognizant of the overall pressures required for safe operations of hydrocarbon storage caverns based on years of experience and will never permit leakage that would jeopardize the public or USDW. Finger Lakes will monitor well head pressures of its storage wells on a daily basis and the procedure for this will be addressed in the facility's Operations Manual.

Finger Lakes intends to have in place, prior to the commencement of operations, a number of different manuals or programs, all designed to prevent accidents. This will be accomplished through an Operations Manual, a Spill Prevention and Control Manual, a Hazard Communication and Assessment Program, a Safety Manual, and a Facility Security Manual.

Each of these manuals will contain the necessary information for safe operation of the Facility. Safe operations are accomplished via training. Employees will be required to take computer based training every two (2) years at a minimum. In addition to the computer-based training, each employee will experience at least six months on the job during which specific training and monthly safety meetings are given to reinforce the computer based training. Also, task specific safety meetings will be held.

Every employee will be familiar with Material Safety Data Sheets ("MSDS"), personal protective equipment required, and the contents of each of the manuals. The MSDS's for propane and butane are attached as **Exhibits 23 and 24**, respectively. An MSDS for mercaptan is attached as **Exhibit 25**.

Operating procedures, wellhead controls and check valves will be installed to ensure safety and prevent accidents. A description of the engineered Safety Controls on the caverns will be included in the Operations Manual.

The Facility will maintain an Emergency Response Manual (some or all of which may be contained in the other referenced materials). Prior to any injection of storage LPG, Finger Lakes will provide two (2) copies of the Emergency Response Manual to the DEC (Director, Bureau of Oil & Gas Regulation).

15. <u>Mechanical Integrity Testing Procedures</u>

MITs are performed at a pressure greater than normal operating pressures. The procedure for MITs is attached hereto as **Exhibit 26**. The purpose of an MIT is to show that the structural part of the cavern that protects the Underground Source of Drinking Water (USDW) will not allow gas to penetrate those formations. MIT pressures are above operating pressures but still significantly below the safe working pressures of the pipe and cement, and even further below the lithostatic pressures above the cavern and the compression that the cavern roof and salt walls can withstand. MITs are short duration tests and the existing wells and caverns have always passed these tests without any significant loss of pressure.

Even more compelling, however, are the long term in-situ tests that have been performed on the caverns showing that those caverns do not leak even when subjected to much higher than normal operating pressures for weeks or months. Finger Lakes will monitor pressures on its caverns on a daily basis so that any leak would be detected quickly.

Finger Lakes understands that DEC requires nitrogen interface MIT tests at all wells prior to first injection of product and at five-year intervals thereafter as nitrogen testing is the industry standard for testing gas tightness in storage caverns. Inergy currently performs its MITs at five year intervals, and Finger Lakes proposes to conduct MITs on the wells that are the subject of this Application at five-year intervals in the future.

All MIT testing pressures are based on a 0.8 psi hydrotest/hydrostatic pressure, and 0.75 psi nitrogen interface MIT test as follows, respectively, and such pressures are included in the Geomechanical study that is being performed.

Well No.	Hydrotest/Nitrogen Interface
Well 33 – casing seat cemented at 1,975'-	1,580 psi/1,481 psi.
Well 43 – casing seat cemented at 2,117'-	1,694 psi/1,588 psi.
Well 44 – casing seat cemented at 2,423'-	1,938 psi/1,817 psi.
Well 58 – casing seat cemented at 2,183'-	1,746 psi/1,637 psi.

16. **Conclusions**

State-of-the art sonars and hydrotesting has been performed on the gallery shown as Finger Lakes Gallery 1 (wells 33, 43, 34 and 44) and Gallery 2 (well 58). That testing shows the shape of the caverns and reflects the success of the hydrotest in each of the cavern wells in Gallery 1 and 2. Careful evaluation was performed to study the well core and logs, including casing inspection, cement bond, gamma ray and neutron logging, and detailed studies of the related geology and geomechanical analysis (FEA). Inergy/Finger Lakes is confident that the aforementioned galleries will be safe to operate LPG injections and withdrawals under constant hydraulic pressures.

17. **References**

a. Jacoby, C.H., Dellwig, L.F., 1974, Appalachian Foreland Thrusting in Salina Salt, Watkins Glen, New York, 4th International Symposium on Salt, Northern Ohio Geological Society, Inc., pp. 227-233

b. Jacoby, C.H., 1963, International Salt Brine Field at Watkins Glen, New York, Symposium on Salt, Northern Ohio Geological Society, Inc., 506-520

c. Jacoby, C.H., Use of Abandoned Solution-Mined Cavities for Storage of Plant Waste, Transactions, Society of Mining Engineers, AIME, Vol. 254, pp. 364-67, December 1973

d. Jacoby, C.H., Szyprowski, S., Paul, Dilip K., Earth Science Aspects in the Disposal of Inorganic Wastes, 4th International Symposium on Salt, Northern Ohio Geological Society, Inc., pp. 307-12

e. Levorsen, A.I., 1954, Geology of Petroleum, W.H. Freeman & Co., San Francisco, 724 p.

f. RE/SPEC, Inc., January 1996, Coring Activities – NYSEG Well 59, Seneca Lake Storage Project, Watkins Glen, New York; Topical Report RSI-0655

g. RE/SPEC, Inc., January 1996Mechanical Properties of Salt and Dolostone from AKZO Nobel Salt, Inc., Well No. 58 and NYSEG Well No. 59, Seneca Lake Storage Project, Watkins Glen, New York, Topical Report RSI-0668

h. Rickard, L.V., 1969, Stratigraphy of the Upper Silurian Salina Group – New York, Pennsylvania, Ohio, Ontario, Map and Chart Series No. 12, NYS Education Department

18. <u>List of Exhibits</u>

Exhibit 1 –	General Location Map
Exhibit 2	
	Map 1 – Gallery Map (with existing well status and information, API Numbers, gallery outlines, distances to other wells)
	Map 2 – Overall Site Plan
Exhibit 3 –	Stratigraphic Columns
Exhibit 4 –	Anticline/Syncline Structure Map
Exhibit 5 –	Well 58 Core Log
Exhibit 6 –	Well 58 Compensated Neutron – Density Log for 1992 drilling activities
Exhibit 7 –	Well 58 Sonar for 2009 Sonar
Exhibit 8 –	Well 58 Gamma Ray Segmented Bond Log, Gamma Ray Neutron Log and Microvertilog for 2009 drilling activities
Exhibit 9 –	Well Status and Condition Report
Exhibit 10 –	Well diagrams
Exhibit 11 –	Hydrotest Data for Gallery 1
Exhibit 12 –	Well 58 Long Term Brine Test Report dated February 26, 2010
Exhibit 13 –	Well 58 Mechanical Integrity Test, dated February 24, 2010, submitted to EPA
Exhibit 14 –	Well 52 logs and directional survey for 2009 drilling and sonar activity
Exhibit 15 –	Camillus Shale Isopach Map
Exhibit 16 –	Camillus Shale Structure Map
Exhibit 17 –	Cross-Sections
Exhibit 18 –	Core Descriptions for Well 59 (see references, Section 17(f))
Exhibit 19 –	Rock Mechanics Report for Wells 58 and 59 (see references, Section 17(g))
Exhibit 20 –	Finite Element Analysis
Exhibit 21 –	Capacity Matrix
Exhibit 22 –	Seismic Risk Map

Exhibit 23 – MSDS for Propane
Exhibit 24 – MSDS for Butane
Exhibit 25 – MSDS for Mercaptan
Exhibit 26 – MIT Procedures